External EOS Protection Devices

TI Precision Labs – ADCs

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Prepared by Dale Li
Schottky Diode vs PN Diode

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Schottky Diode</th>
<th>PN Junction Diode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction Type</td>
<td>Metal-semiconductor</td>
<td>Semiconductor-semiconductor</td>
</tr>
<tr>
<td>Forward Voltage</td>
<td>Small - typically 0.3V</td>
<td>Large - typically 0.7V</td>
</tr>
<tr>
<td>Capacitance and Variation</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Reverse Leakage Current</td>
<td>Higher current but less temperature dependence</td>
<td>Lower current, but greater temperature dependence</td>
</tr>
<tr>
<td>Reserve Voltage</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Switching speed and Recovery time</td>
<td>Faster because of majority carrier transport</td>
<td>Limited by the recombination time of injected minority carriers</td>
</tr>
</tbody>
</table>
Unidirectional TVS Diode
(Transient Voltage Suppressor)

Symbol | Parameter |
---|---|
$V_{BR}$ | Breakdown voltage |
$V_R$ | Stand-off voltage |
$V_C$ | Clamping voltage |
$V_F$ | Forward voltage drop |
$I_{BR}$ | Breakdown Current @ $V_{BR}$ |
$I_R$ | Reverse Leakage @ $V_R$ |
$I_F$ | Forward Current @ $V_F$ |
$I_{PP}$ | Peak Pulse current @ $V_C$ |

TVS.uni
Bidirectional TVS Diode
(Transient Voltage Suppressor)

Symbol
$V_{BR}$
$V_R$
$V_C$
$V_F$
$I_{BR}$
$I_R$
$I_F$
$I_{PP}$

Parameter
Breakdown voltage
Stand-off voltage
Clamping voltage
Forward voltage drop
Breakdown Current @ $V_{BR}$
Reverse Leakage @ $V_R$
Forward Current @ $V_F$
Peak Pulse current @ $V_C$
TVS vs. Zener

• TVS Diode
  – Solid state PN junction
  – Designed for operation in reverse-breakdown region only during over-voltage events
  – Junction area sized to conduct significant current and absorb significant power
  – Specifically designed for large transients such as ESD
  – Can react to overvoltage in pico-seconds

• Zener
  – Solid state PN junction
  – Designed for full-time operation in reverse-breakdown region
  – Ideal for voltage regulation
  – Slower reaction time
  – Lower current/power capability

Zener Diode
Current and Power Ratings on TVS diodes

- **Peak Pulse Current (I_{PP})**
- **Pulse Waveshape**: 8µs/20µs
- **50% Pulse Width (t_d)**: 8µs
- **100% Pulse Width (t_d)**: 20µs
- **Rise Time (t_r)**
- **Peak Pulse Power**: kW
- **Pulse Duration (t_D)** (µs)

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PULSE DURATION, t_d (µs)</th>
<th>PEAK PULSE POWER P_{PP} (W)</th>
<th>MAX. CLAMPING VOLTAGE V_C AT I_{PP} (V)</th>
<th>PEAK PULSE CURRENT I_{PP} (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMF13CA</td>
<td>10/1000</td>
<td>200</td>
<td>21.5</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>8/20</td>
<td>950</td>
<td>21.5</td>
<td>44.2</td>
</tr>
</tbody>
</table>

- **Peak Pulse Power**: 950W
- **200W**
- **20µs** 1000µs
- **1000µs**
Current and Power Ratings on TVS diodes

Steady State Power Dissipation (W) vs. Temperature (°C)

Peak Pulse Power Derating (%) vs. Temperature (°C)
Thanks for your time!
Please try the quiz.
Questions: External EOS Protection Devices

1. What are the main reasons to use a Schottky diode rather than a PN diode for input protection?
   a. Low forward voltage
   b. Fast switching
   c. High reverse breakdown
   d. Low leakage current
   e. Both a and b
   f. Both c and d

2. (T/F) In some cases a PN type diode may be used in place of a Schottky diode because of it’s low leakage current.
   a. True
   b. False
Questions: External EOS Protection Devices

3. What are the main reasons to use a TVS diode rather than a Zener diode for input protection?
   a. Better accuracy
   b. Lower noise
   c. Larger power rating
   d. Faster switching time
   e. Both a and b
   f. Both c and d

4. (T/F) The peak power rating will be lower than the continuous power rating on a TVS diode.
   a. True
   b. False
Questions: External EOS Protection Devices

5. Which of the following is **NOT** true for a TVS diode with a peak pulse power rating of 200W for a 10/1000µs pulse?
   a. The rise time is 10µs, and the pulse width is 1000µs
   b. The amplitude of the current will drop to 50% at 1000µs
   c. The amplitude of the current will drop to 10% at 1000µs
   d. The power rating will be lower for higher temperature

6. If the normal linear input range of the ADC is ±10V, which parameter on the TVS diode should be set to 10V or greater?
   a. Breakdown voltage
   b. Stand-off voltage
   c. Clamping Voltage
   d. Breakdown Voltage
Thanks for your time!